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SAR Applications in the 21st Century

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Abstract

SAR image data from a variety of spaceborne and airborne sensors will be much more commonplace in the early 21st cent ury. Why will SAR data be used in some applications and what will it be used for? Part of the answer lies in SAR's ability to provide high-resolution imagery, independent of cloud cover or sun illumination, and in the sensitivity of radar measurements to certain physical characteristics of the area being imaged, such as surface roughness, structure, dielectric constant and, to some extent, motion. Another part of the answer is provided by the high-resolution topography and topographic change maps which can be generated using the technique of SAR interferometry.

1. Introduction

Synthetic Aperture Radar (SAR) has progressed from it's development in the. 1950’s as a technique for improving the resolution of military reconnaissance radars to the present day, when it is rapidly maturing, as a remote sensing tool for many civilian applications. Many countries now have their own airborne SAR systems and so far, in the first half of the 1990s, SAR data has been available to scientists and applications users from three spaceborne missions: ERS-1, JERS- 1 and SIR-C/X-SAR. With the. recent launch of ERS-2 and the projected launch of Radarsat later this year, even more SAR data will be available. in the. near future.. Looking forward just a few years to the 21st century, space agencies from several countries or groups of nations have plans to launch further SAR sensors into orbit, including Russia, Japan, Canada, India, the European Space Agency and NASA.

The results of ERS, JERS-1 and SIR-C/X-SAR have confirmed the importance of multi-angle, multi-frequency, multi-polarization, and multi-temporal SAR observat ions for Earth Science research and operational applications, Evans et al [1]. In addition, radar interferometry has been shown to hold the potential for making major advances in our understanding of Earth processes in several discipline.s. Interferometric measurement capabilities arc required to generate global topographic maps, to monitor surface topographic change, and to monitor glacier ice. velocity and ocean currents. Frequency and polarization diversity arc crucial for accurate. land cover classification in tropical and Arctic regions, measuring above-ground woody plant biomass, delineation of wetland inundation, measurement of snow and soil moisture, characterization of oil slicks, arid monitoring of sea icc thickness 3’here. is also a demonstrated need for variable swath widths (e.g. 50 to S00 km) and resolutions (5 to SO m), with the ability to collect coarser resolution data with repeat cycles ranging from 3 to 2.5 days. If a single sensor is to satisfy multiple objectives, a variable incidence angle is also required to improve coverage and satisfy disparate viewing requirements. There is a demand from operational and commercial users for data products that are ortho-rectified, with con ections for terrain height and slope already applied. This makes the data much easier to incorporate into existing GI S systems and allows for straightforward fusion of SAR data with data from other sensors and from ground - base.d sources. Interferometric SAR data can meet this requirement for routine, automated ortho-rectification.

2. Multi-Frequency and Polarimetric SAR

SARS arc active sensors, which means that they provide the.ir own illumination. 1 ‘or most SARS this involves the repeated transmission of a high-power (typically a few kilowatts) pulse, sideways and towards the Earth's surface, as shown in Figure 1. The wavelength and

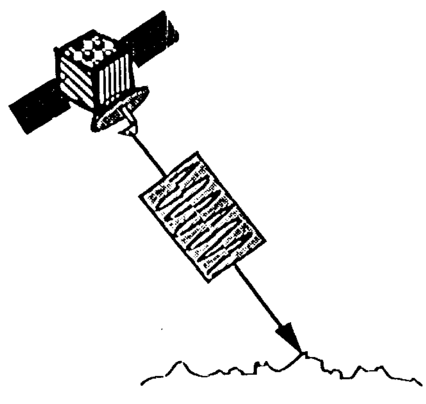


Figure 1. Transmission of a radar pulse towards the Earth's surf ace..

polarization of the transmitted pulse are often fixed, e.g. ERS-1, JERS-1 and Radarsat SARs. In the case of SIR-C/X-SAR, the wavelength of the transmitted pulse could be selected from a choice of three (3 cm, 6 cm and 24 cm) and, for two of those wavelengths the transmitted pulse could be chosen as horizontally (H) or vertically (V) polarized. SIR-C/X-SAR was configured to transmit pulses at all three frequencies at the same time, alternating between H and V polarization at the 6 cm and 24 cm wavelengths.

Energy transmitted by a SAR sensor is scattered during its interaction with the Earth's surface (see Figure 2). Some of the energy is scattered back towards the radar. It is this backscatter energy which is represented in a SAR image. The SAR sensor will be tuned to look at the backscatter at the same wavelength as the transmitted pulse. The polarization of the scattered energy may also be altered by the scattering process. The SAR sensor may be configured to receive the same polarization as that transmitted or to receive a polarization orthogonal to that transmitted. In the case of SIR-C/X-SAR, both H and V polarizations were received at 6 cm and 24 cm wavelengths. If a radar transmits and receives both H and V polarizations it is said to be a *polarimetric* radar.

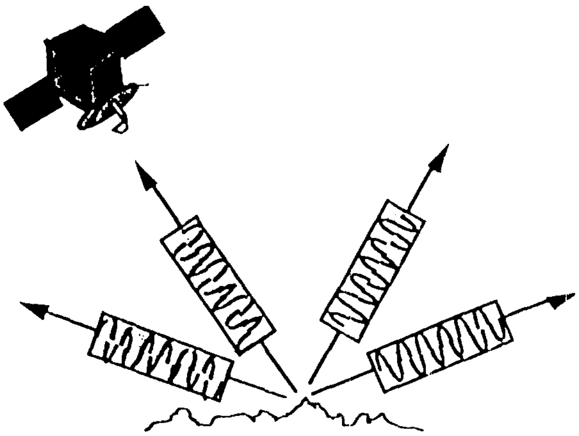
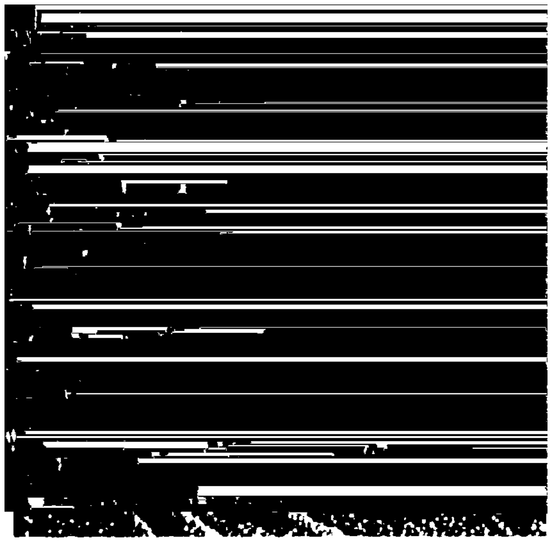


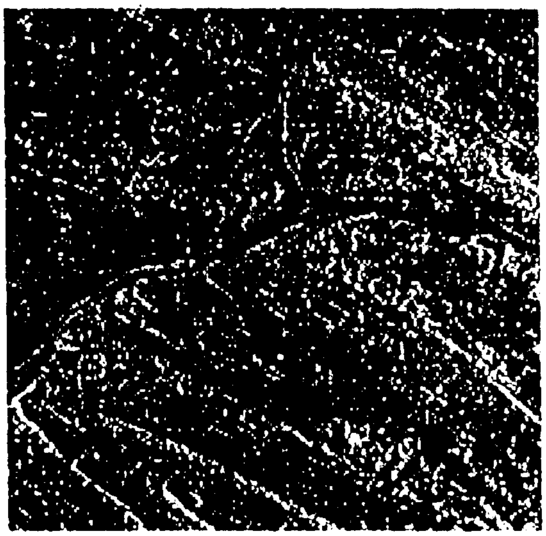
Figure 2. Radar scattering off the Earth's surface

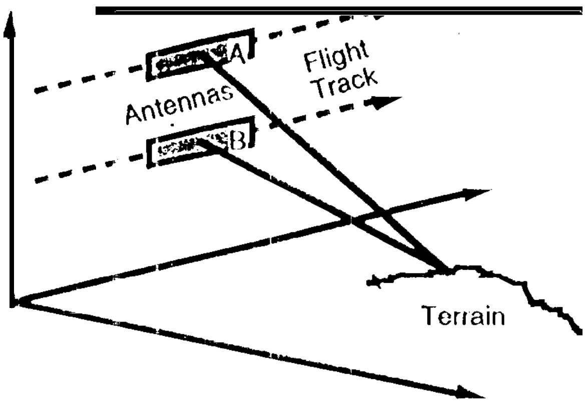
In the L-band image the wooded hills in the top right-hand corner and at lower left appear brighter than the agricultural valleys in between. In the X-band image there is very little contrast between the hills and agricultural areas: this is because the X-band radar 'sees' only the top of the vegetation canopy.



lend to reveal differences in land use. shorter wavelength images (X-band and C-hand) tend to show topographic effects.

Different types of scattering affect horizontal and vertical polarizations differently. Compare the SIR-C/ images shown in Figures 3 and 5. Figure 3 shows an L-band VV polarized image, while Figure 5 shows an L-band HV polarized image. in the HV





in a recent workshop report [3] this technique, known as Differential Interferometry, has enormous potential in mapping the effects of earthquakes, volcanic expansion, and ice sheet motion over large areas. Small-scale. shifts on the order of a centimeter have been measured at a number of sites around the. world. On completion of its mapping phase, the proposed TOPSAT system would stay in orbit to collect this type of data at selected sites around the world.

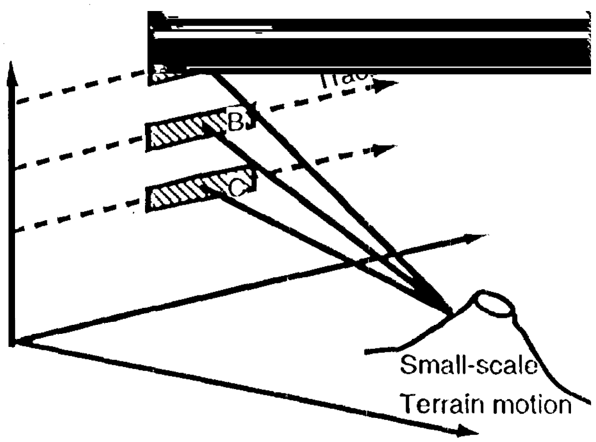
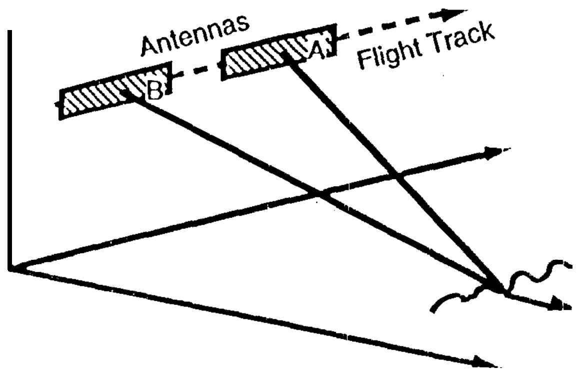


Figure 7. Configuration of 3 SAR antennas (A, B and C) for Differential



interferometry has